

# Normal and abnormal refraction

# New ophthalmology course AFCM

Normal and abnormal



# ILOs

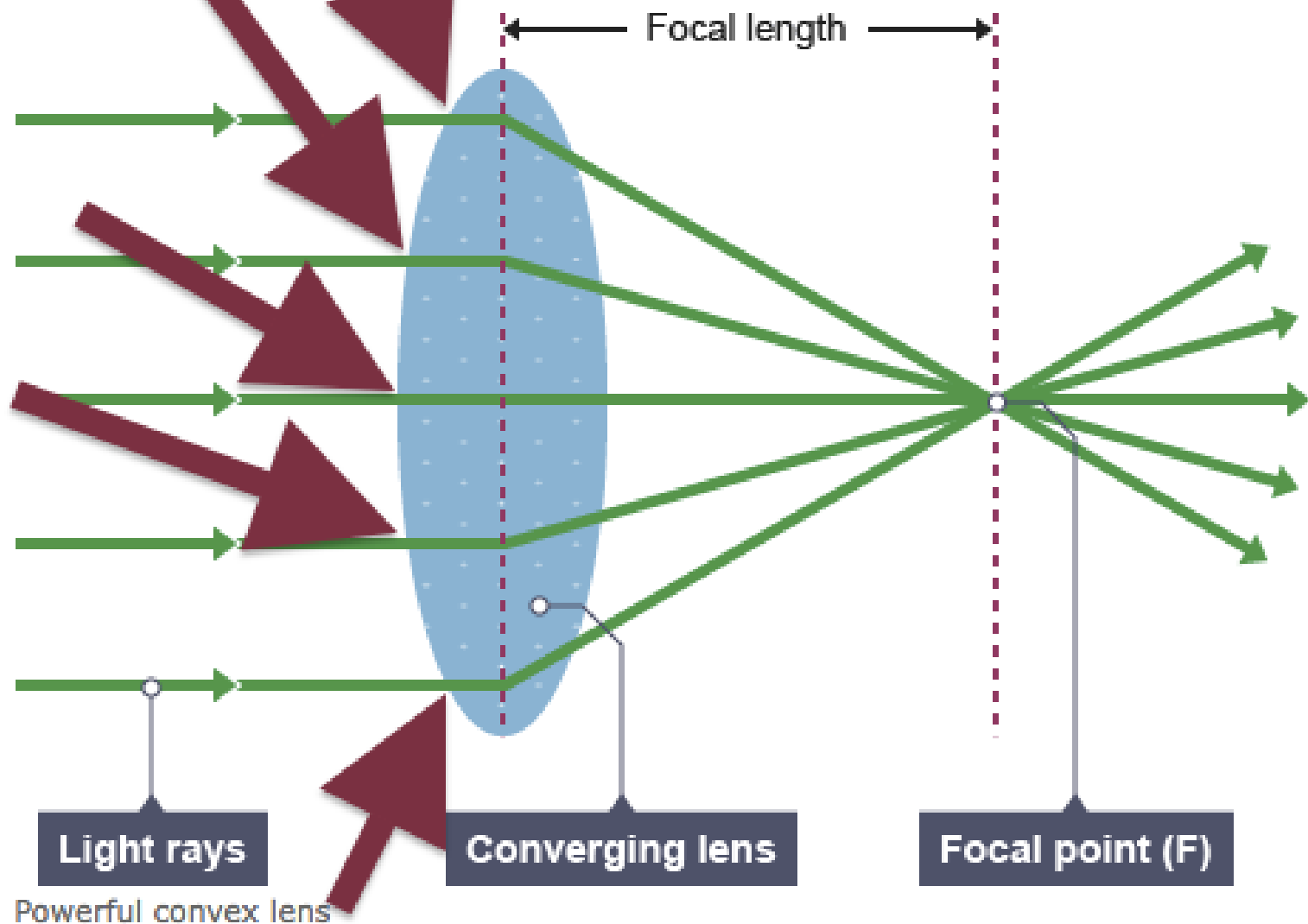
To know principle of normal refraction  
To identify different errors of refraction  
To put treatment plan of different errors of refraction

# Definitions

- A **diopter** is the power of a lens whose focal distance is **1** meter.
- The focal distance lies between the **nodal** point and the **focal** point.

## How do lenses work?

A **converging lens** uses **refraction** to bend the light rays coming out of it inwards. This has the effect of focusing the light to a point called the **focal point**.



# Normal refraction state:

## Emmetropia

- The eye has 2 functional lenses; the cornea (**theoretical** power 42D) and the crystalline lens (16-18D)
- Thus the **theoretical** power of the combined lens is around 58-60D; this creates a focal length of  $100/60 = 1.67\text{cm} = 16.7\text{mm}$
- This distance (1.67cm) should **theoretically** be the exact distance between the **nodal** point of the optical system of the eye and the **sensory** layer of the retina for **emmetropia** (sharp retinal image).

# Emmetropia

- We are born with small eyes (16mm) that reach the adult size (23mm) around the age of 3-4yrs.

*BETWEEN BIRTH AND 4 YRS, all **children** are theoretically **hypermetropes**.*

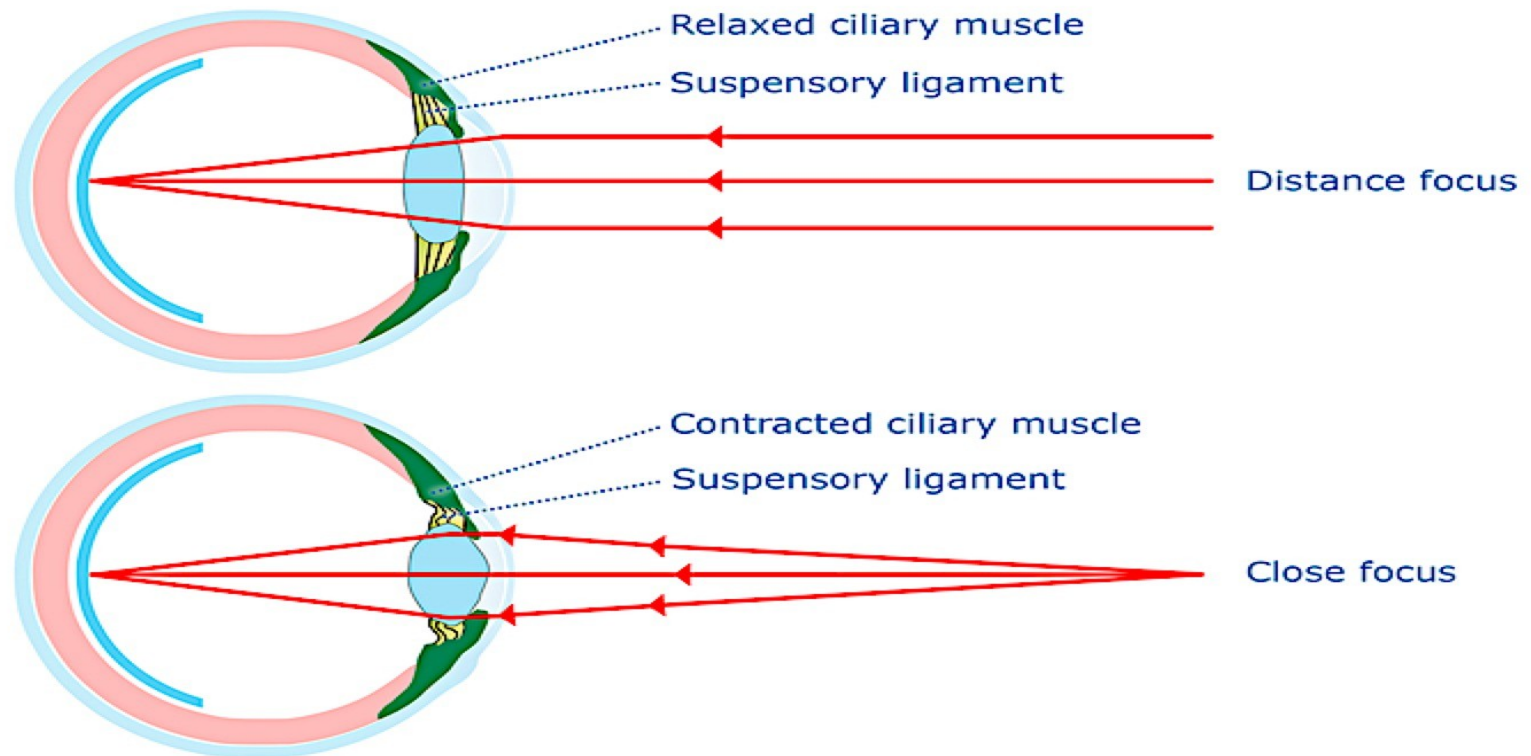
- **Some** people overgrow the final size of 23mm and become **myopes**.
- **Every 1mm increase** in axial length causes **3D of myopia**.

# Accommodation

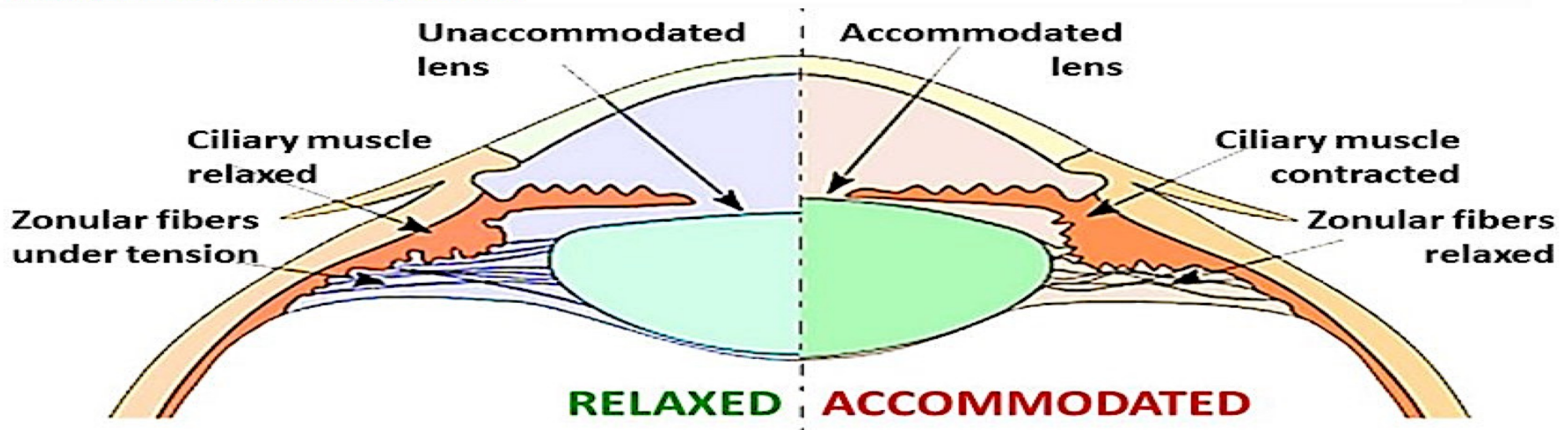
- Is the ability of the eye to **increase** its refractive power to see **near** objects.
- It results from the **contraction** of the ciliary muscle → **relaxation** of the suspensory **zonule** → increased lens curvature.
- Its power declines with age, and above **45yrs** it is not sufficient for **comfortable** near work.
- Amplitude of accommodation: calculated by  $100/\text{near point of distinct vision in cm}$ ,
- e.g. If near point is 20cm, then amplitude of accommodation =  $100/20 = 5\text{D}$ .



## How the eye focuses light



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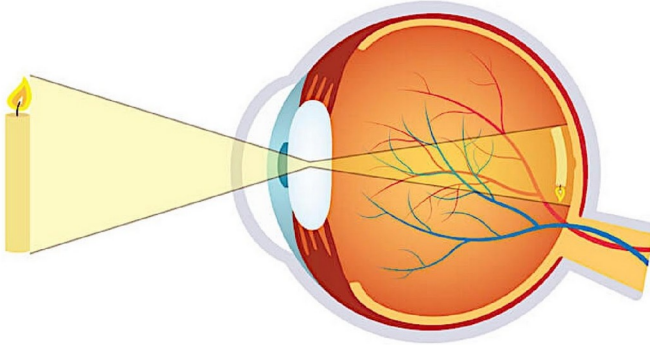
# Ametropia: spherical errors

Errors of refraction occur in one of 2 general situations\*

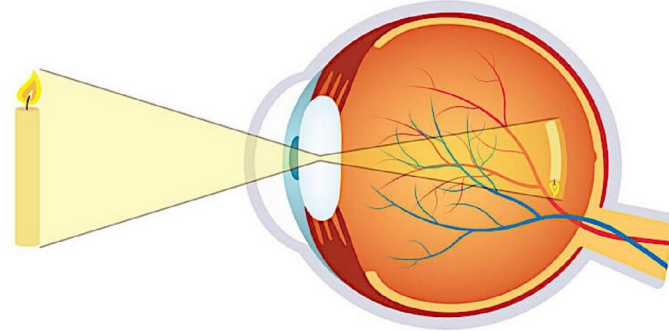
1. If the **power** of the combined lens is more or less than the **theoretical** 60D **refractive ametropia**
2. If the **distance of the retina** is more than or less than the **theoretical** 1.67cm **axial ametropia**
  - If the power of the combined lens is **higher** or the retina is **farther** (larger eyeball); the condition of **myopia** results
  - If the power is **lower** or the retina is **closer** to the nodal point (small eye); the condition of **hypermetropia** results
  - **Aphakia** is a form of **extreme hypermetropia** in which the crystalline lens is absent (power reduced from 60 to 42D)
  - **Pseudophakia** is the **artificial lens** implanted after cataract extraction.

\*the numbers are approximate for illustration

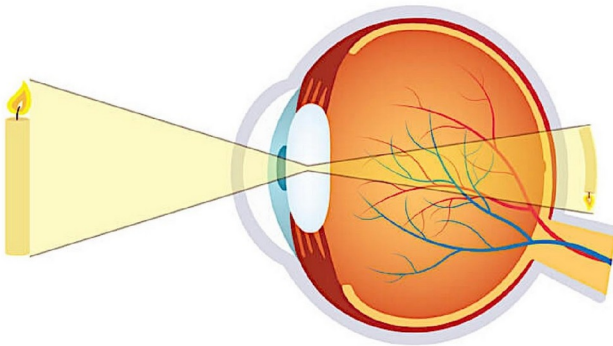
# VISION DISORDERS



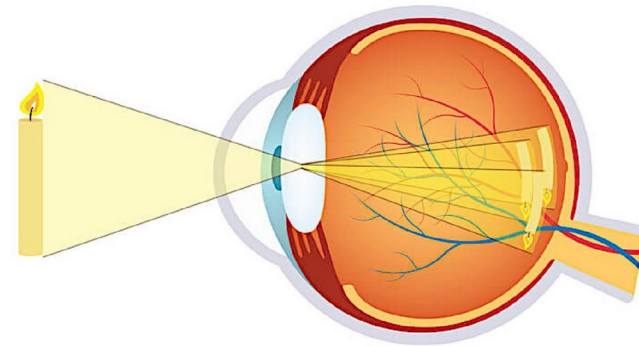
Normal vision



Myopia



Hyperopia



Astigmatism

# Visual Acuity

- Normal VA is 6/6 or 20/20
- the Snellen test is a test of minimum separable acuity, it is the clinically preferred acuity test.
- A rating of 6/24 means that a letter that normally should be read at 24 METER has to be brought to within 6 METER before it is recognized by the patient.



# Myopia

- Is a **refractive** condition in which **parallel** rays, with accommodation relaxed, come to focus **in front of** the retina
  - Because the **retina** is **farther** (axial M)
  - Or the combined lens is **stronger** (refractive M)
- Generally there are 2 types of myopia
  - Simple or school myopia
  - Malignant or progressive myopia

# Myopia

## **SIMPLE**

- Not genetic (excessive near work in early life)
- Starts after age of 10yrs.
- Progresses slowly
- Does not exceed -6.0D
- Arrests at age of 20yrs.
- Does not cause degenerative changes
- RD is not common
- Corrected by laser refractive surgery

## **PROGRESSIVE**

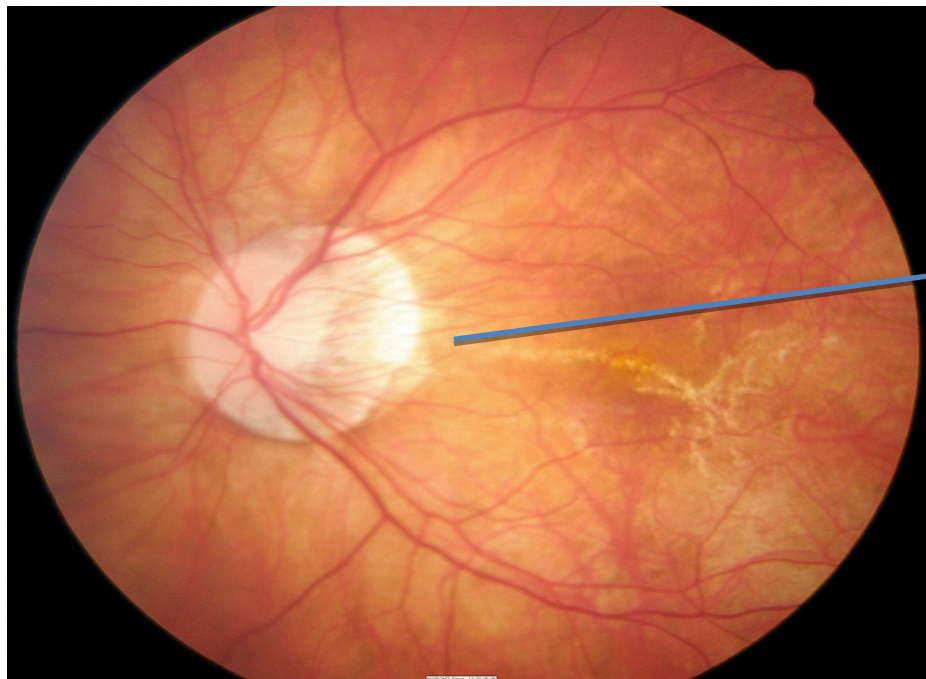
- Genetic (high incidence is certain races and families)
- Usually before 10yrs.
- Progresses rapidly
- Unlimited in amount
- Does not arrest at age 20
- Causes many degenerative changes in the fundus
- RD is very common
- Cannot be corrected by laser surgery

# Degenerative myopia

- Large globe---apparent **proptosis**
- True exotropia
- Deep AC
- Open-angle glaucoma
- Complicated cataract
- Vitreous liquefaction---musca and flashes
- Posterior staphyloma
- Retina degenerations **flash of light**
- Choroidal degeneration



# Normal fundus

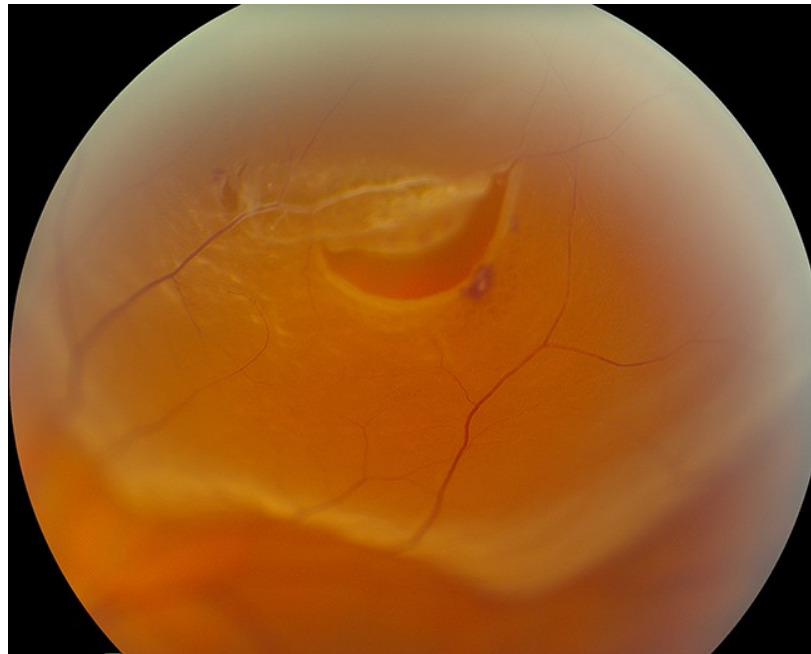
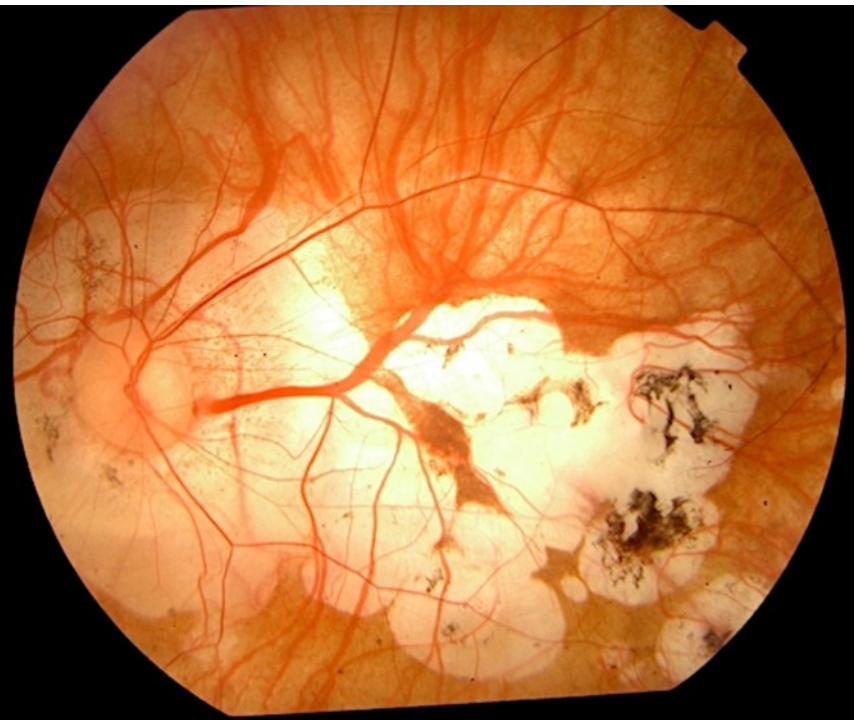


**Tigroid fundus with  
temporal crescent  
sclera & lacquer cracks  
degeneration**





**Chorioretinal**



**Retinal  
detachment**

# Myopia: correction

- Myopia is corrected by **concave (-) lenses** to decrease the power of the combined lens to 60D
- Eg. If the power of the combined eye lens is 62D, the patient is said to be -2.0 myope and is given -2.0 concave lens
- Cosmetically bad eyeglasses can be replaced by **contact lenses**
- **Refractive surgery**

# Hypermetropia

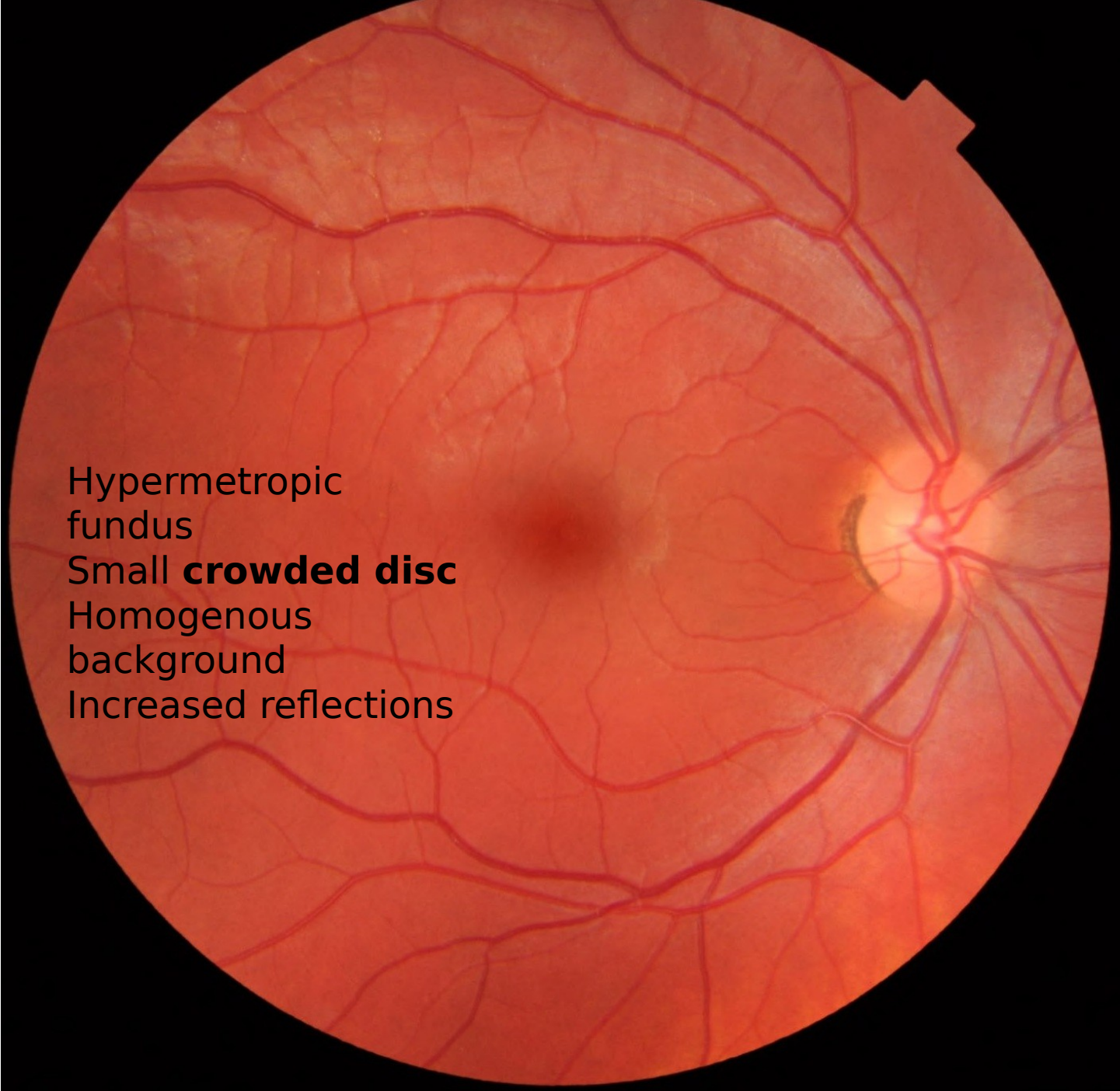
- Is a refractive condition in which **parallel** rays, with accommodation relaxed, come to focus **behind** the retina.
  - Because the **retina** is **closer** (axial H)
  - Or the combined lens is **weaker** (refractive H)
- Accommodation **can** correct hypermetropia
- The part corrected by accommodation is called **FACULTATIVE** hypermetropia and the part that cannot be corrected is called **ABSOLUTE** hypermetropia.

# Hypermetropia

- Hypermetropia is a common cause of visual **asthenopia** esp. in children
- **Asthenopia** is a group of symptoms that make near work difficult including headache, blurring of vision, running of letters, desire to sleep, eye redness... etc.

# Hypermetropia

- The eye is small (apparent **enophthalmos**)
- The cornea is small
- The AC is shallow
- The angle is narrow (narrow angle glaucoma)
- The retina is glistening
- The retinal vessels are tortuous
- The disc is small and crowded
- The optic cup is small



Hypermetropic  
fundus  
Small **crowded disc**  
Homogenous  
background  
Increased reflections

This fundus photograph shows the interior surface of the eye. The optic disc is located on the right side, appearing as a bright, circular area where the optic nerve exits the eye. It is surrounded by a network of retinal blood vessels. The background of the fundus is a uniform reddish-orange color, indicating a homogenous background. The overall appearance is consistent with a hypermetropic fundus, characterized by a crowded optic disc and increased reflections.

# Hypermetropia: correction

- Hypermetropia is corrected by **convex (+) lenses** to increase the power of the combined lens to 60D
- Eg. If the power of the combined lens is 58D, the patient is said to be +2.0 hypermetrope and is given +2.0 convex lens
- Contact lenses
- Refractive surgery

# Ametropia: non-spherical errors

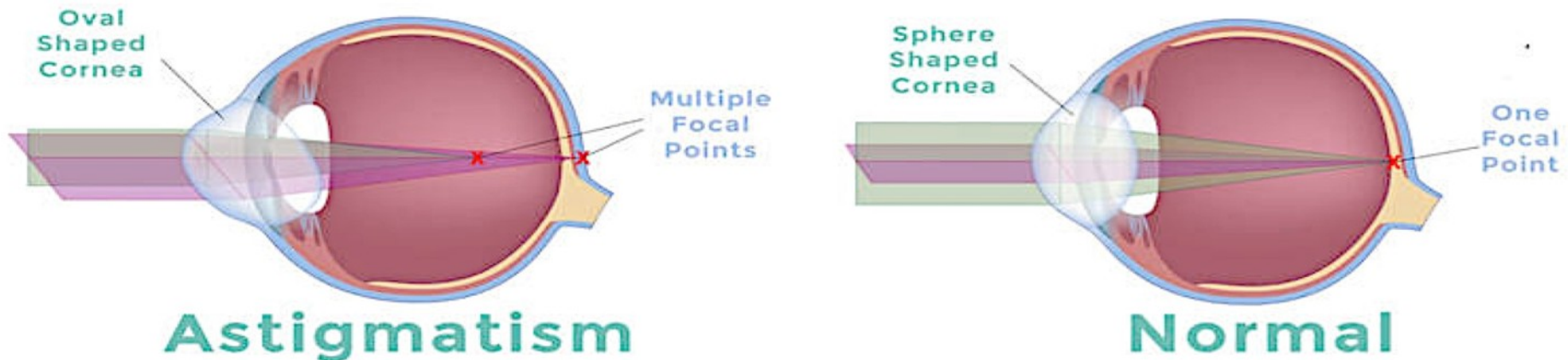
- Astigmatism



# Astigmatism

- Is an error of refraction in which there is **NO** single point focus; vertical rays come to a point focus and horizontal rays come to another point focus
- It results from unequal power of the 2

## What is Astigmatism?



# ASTIGMATISM CAN BE

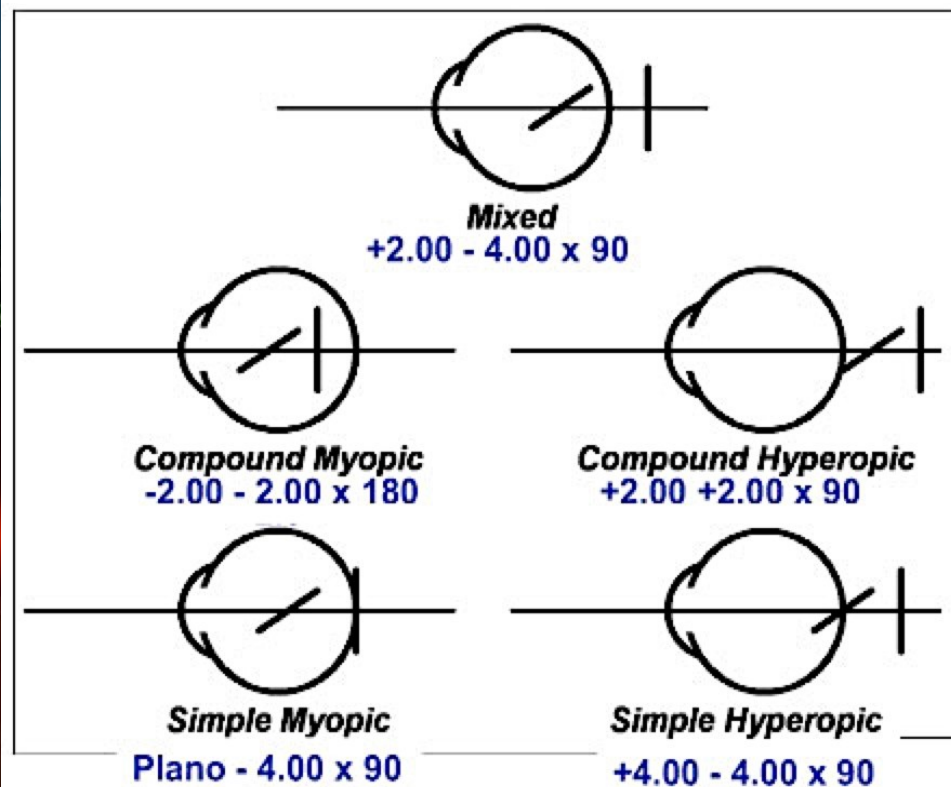
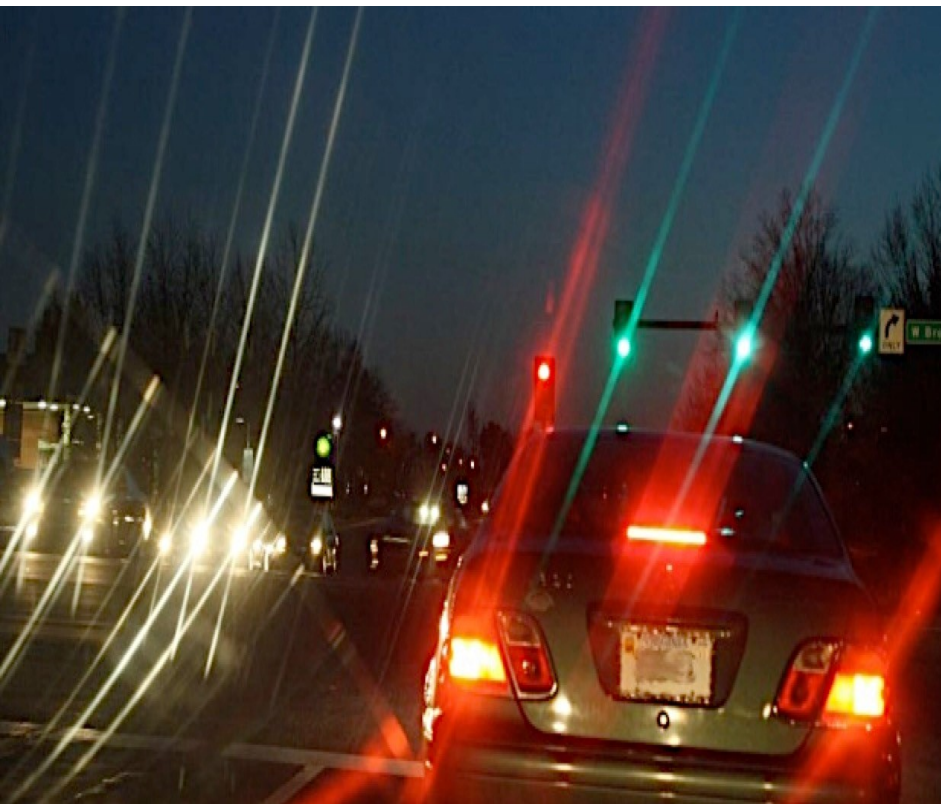
- With **the rule** or **against the rule**

Generally speaking the vertical meridian is more curved (stronger or more **myopic**) than the horizontal meridian. This is called astigmatism WITH THE RULE. The opposite situation is astigmatism AGAINST the rule

- **Vertical** or **oblique**: principal meridians can be 90/180 or 45/135 degrees

- **Regular** or **irregular** as in **keratoconus** or **corneal scars**

- cone-shaped cornea causes blurred vision and may cause sensitivity to light and glare.



- *Regular* Astigmatism is corrected by **cylindrical** lenses that work in one meridian only
- The cylindrical lens works on the meridian **perpendicular** to its axis البايظ
- Irregular astigmatism requires **hard contact** lenses for correction
- Mixed      sphero cylindrical

# Presbyopia

## Asthenopia

Hypermetrope



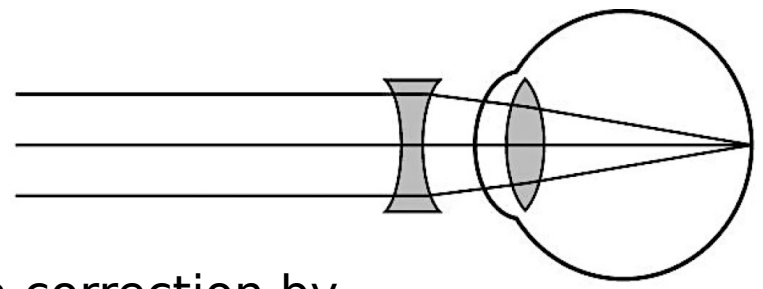
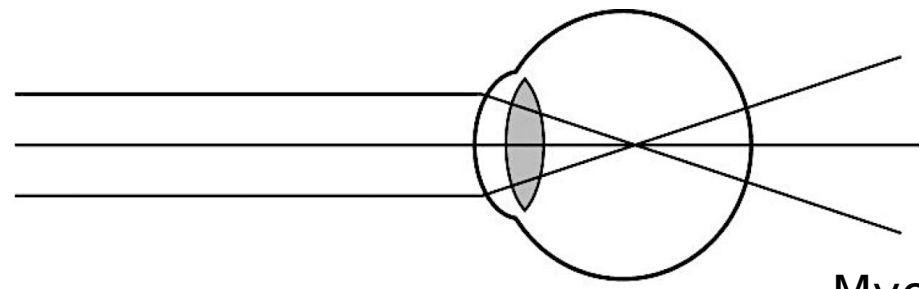
- Is **recession** of the **near** point of clear vision with age above **45yrs.** (weakness of accommodation **before** 45yrs is termed **paresis** of accommodation)
- Results from increased **rigidity** of the crystalline lens with age, which cannot change its shape and increase its power with ciliary muscle contraction in **accommodation**

# Amplitude of accommodation

- Approximate amplitude/age
  - Children: 14D
  - Age 20: around 8D
  - Age 30: around 6D
  - Age 45: around 2.5D
  - Age 50: around 2D
  - Age 60: <1D

# Presbyopia

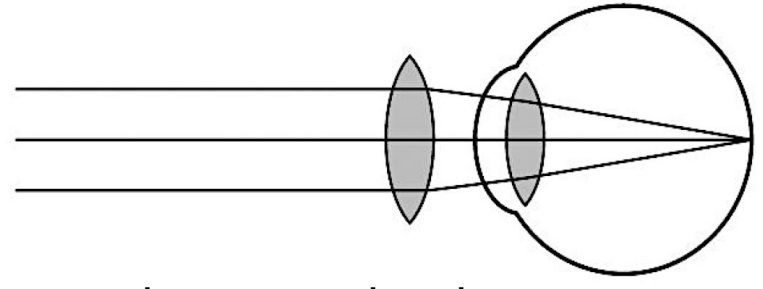
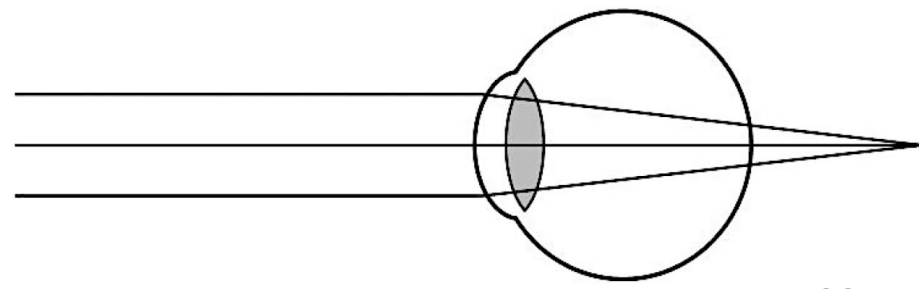
- The patient needs a **reading add** to his distance glasses
- The add ranges from +1.0 to +3.0D depending on the **preferred** working distance
- To calculate the add  $\square 100/\text{working distance in cm}$ . (if **working** distance is laptop-50cms, the required add is  $100/50 = 2\text{D}$ )
- Adds greater than +3D are **not** comfortable



Myopia correction by  
concave lens

**A**

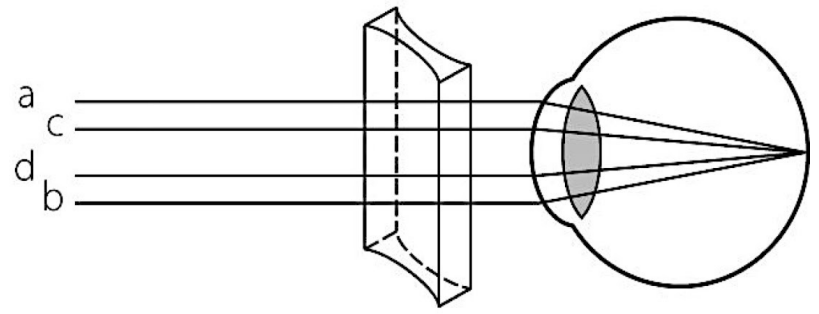
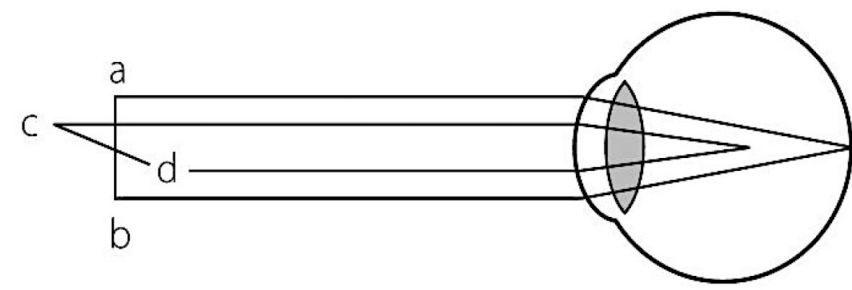
**B**



Hypermetropia correction by  
convex lens

**C**

**D**



Astigmatism correction by  
cylindrical lens

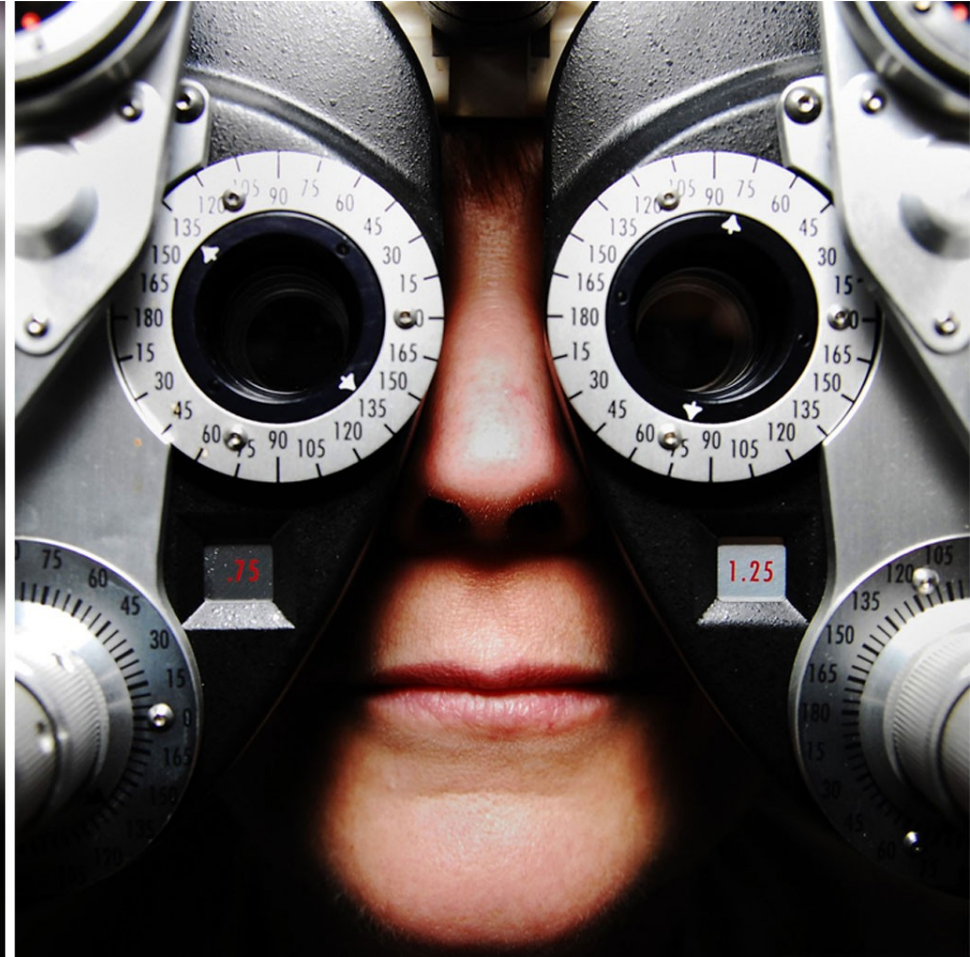
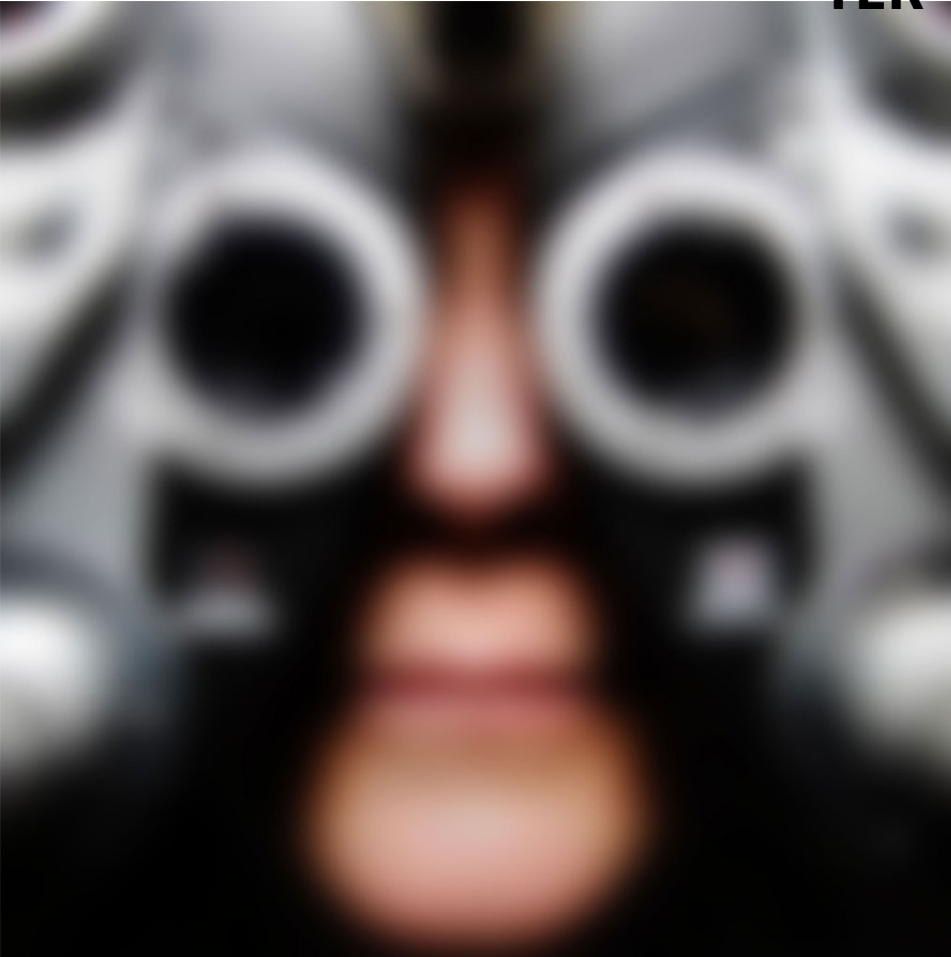
**E**

**F**





# PHOROP TER



# Contact lenses

- Are small lenses worn directly over the cornea to correct errors of refraction
- Contact lenses may be
  - Hard,
  - soft lenses
  - Semirigid
  - Cosmetic
  - Therapeutic

- The most important factor in lens wear is the **proper hygiene** otherwise complications can occur that may be severe
  - Over-wear syndrome
  - Corneal abrasions and ulcers
  - Infectious keratitis [acanthamoeba](#)
  - Giant papillary conjunctivitis

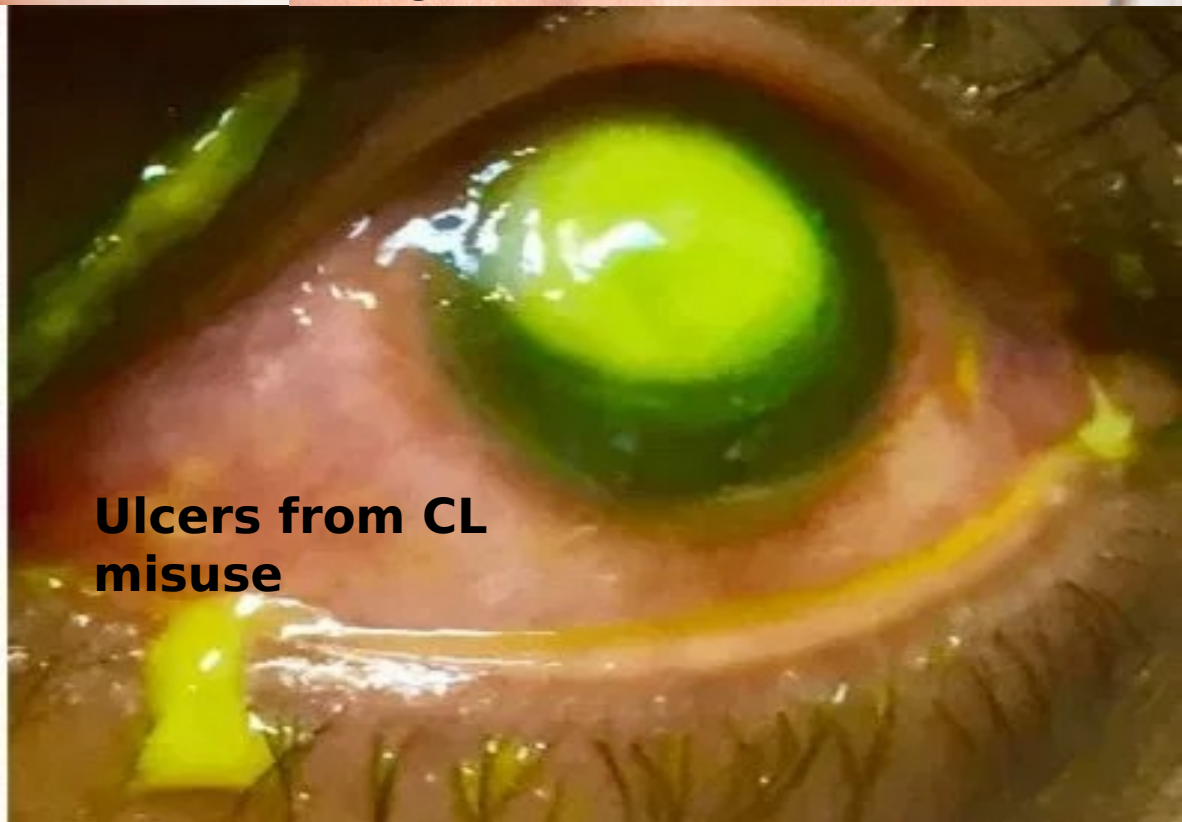




Wearing  
CL



Colored  
CL

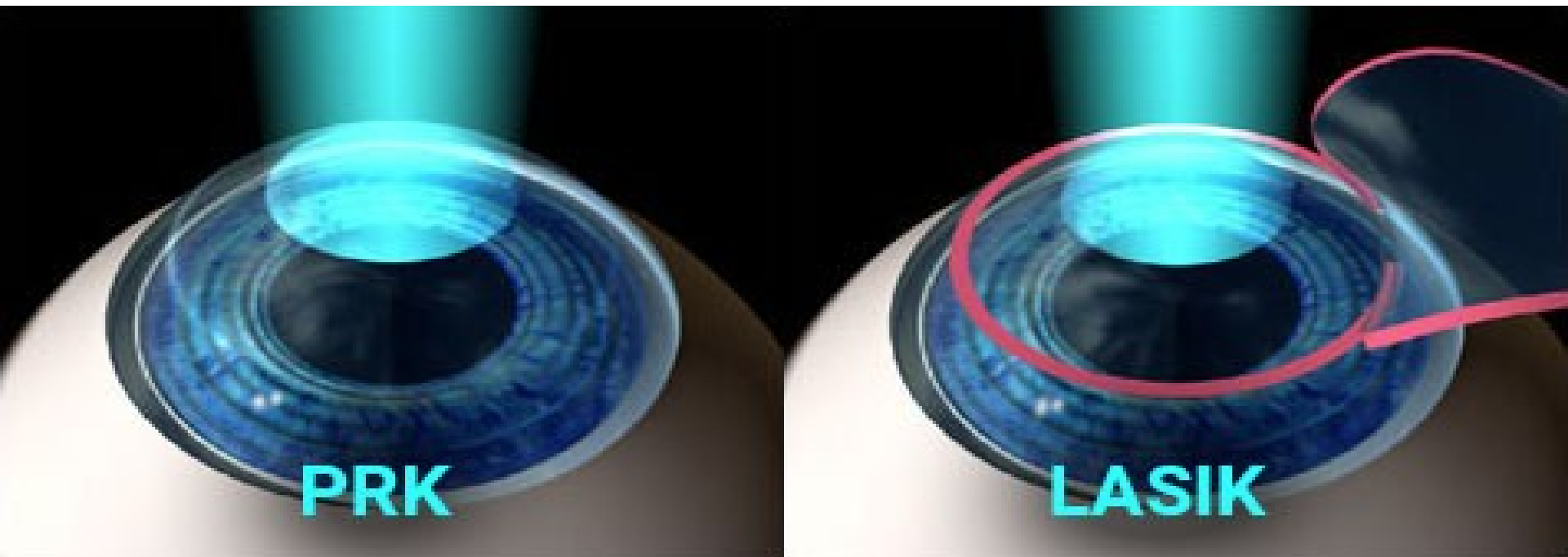


Ulcers from CL  
misuse

# Corneal Refractive surgery

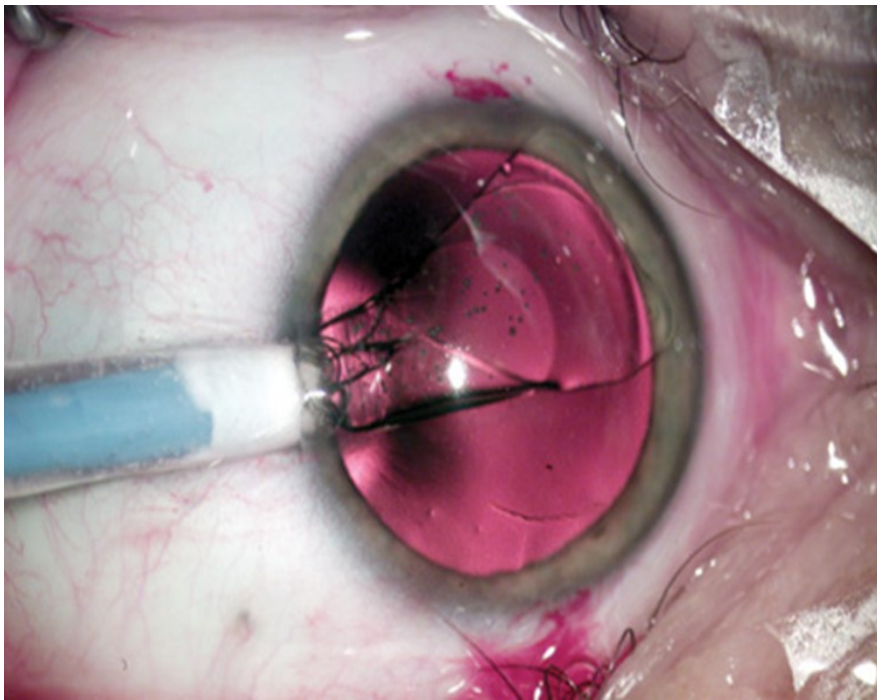
- Most refractive surgeries aim at changing the curvature of the cornea to correct ametropia
- There are general precautions for all refractive surgeries including
  - Appropriate **age** for consent and **stabilization** of error أكبر من 18
  - Suitable corneal **thickness** to avoid post-ablation ectasia
  - Absence of corneal diseases, dystrophies and keratoconus
  - Absence of tear-film problems and dry eye

# Corneal refractive surgery



# Refractive lens surgery

**Phakic IOL**



**Iris Claw phakic IOL**

